The Role of Syntagmatic and Paradigmatic Relations in Brain Organization of Nouns and Verbs Retrieval: an fMRI Study

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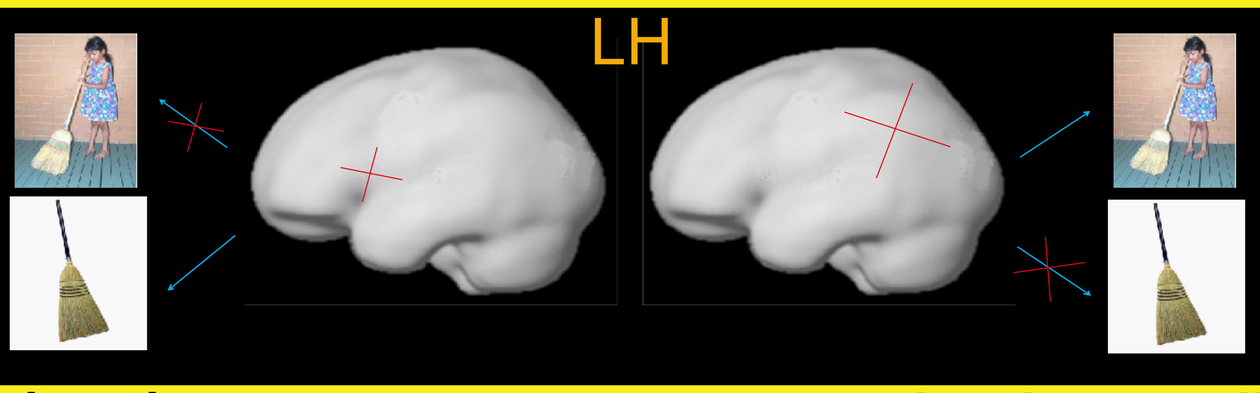
Noun-Verb dissociation

Frontal lobe lesions

Verb retrieval suffer more than noun retrieval



Temporal, temporo-parietal lesions

Noun retrieval suffer more than verb retrieval

Existing explanations

Nouns and verbs have distinct cortical representation: nouns are represented in temporal and temporo-parietal regions and verbs - in frontal lobe (Damasio and Tranel, 1993).

The grammatical function of the verbs leads to dissotiation (Tyler et al. 2004).

The parameters of imginability and image complexity play role (Crepaldi et al., 2004, 2008; Liljestrom et al., 2008).

et cetera.

Another possible explanation

In picture naming task, retrieval of nouns is based on paradigmatic relations between concepts (differentiation) while verb retrieval involves syntagmatic relations (syntactic context). Syntagmatic relations suffer after frontal lobe damage and paradigmatic - after temporal lobe damage (Jacobson, 1944; Luria, 1967).

Thus, in the current study we investigate whether different world retrieval strategies (paradigmatic vs. syntagmatic) rather than world class per se (nouns vs. verbs) contribute to noun-verb dissociation.

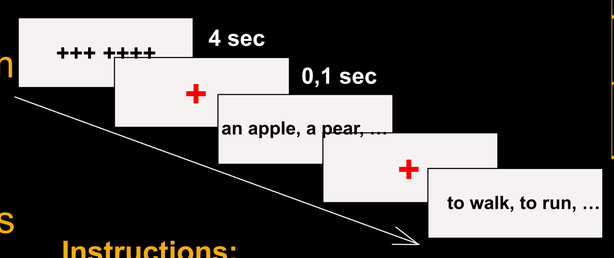
Hypothesis

The %-signal change in the regions of interest (pars triangularis (ptIFG) and pars opercularis of IFG (poIFG), superior temporal sylcus (STS) and temporo-parietal region (TPr)) is influenced by the world retrieval strategies (paradigmatic vs. syntagmatic) rather than world class per se (nouns vs verbs).

Method

Participants:
22 healthy right-handed native Russian speakers (17 females; 5 males; mean age 23 years). Informed consent was obtained from all participants in agreement with the Declaration of Helsinki.

Scanning parameters:
Both structural T1-weighted and functional T2*-weighted volumes (EPI sequence parameters: TR/TE/FA - 2520 ms / 50 ms / 90°; 36 slices oriented parallel to AC/PC plane, slice interval 0.75 mm; voxel size 3.6x3.6x3.8 mm), 234 volumes per session were obtained using Siemens 1.5 T Magnetom Avanto scanner.



Instructions:
Complete overtly a sequence of two words (presented in print on the screen for 4 sec) with a semantically appropriate word and press the bottom.

	Nouns	Verbs
Paradigmatic	an apple, a pear, …	to walk, to run, …
Syntagmatic	The girl eats …	The girl … an apple.

Activation task:
Stimuli were presented in a block design.
Each run lasted about 10 minutes and included 5 blocks of 4 conditions of activation task alternating with 5 blocks of baseline, two sessions.

Data processing: spm8, marsbar-0,45.

Results

%-signal shange in ROIs


Fig.1 poIFG

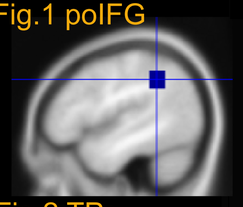


Fig.2 TPr

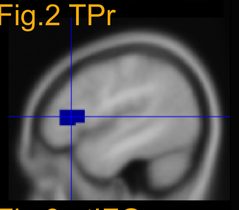


Fig.3 ptIFG

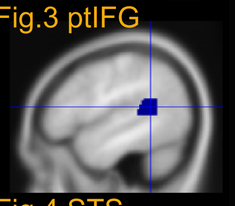
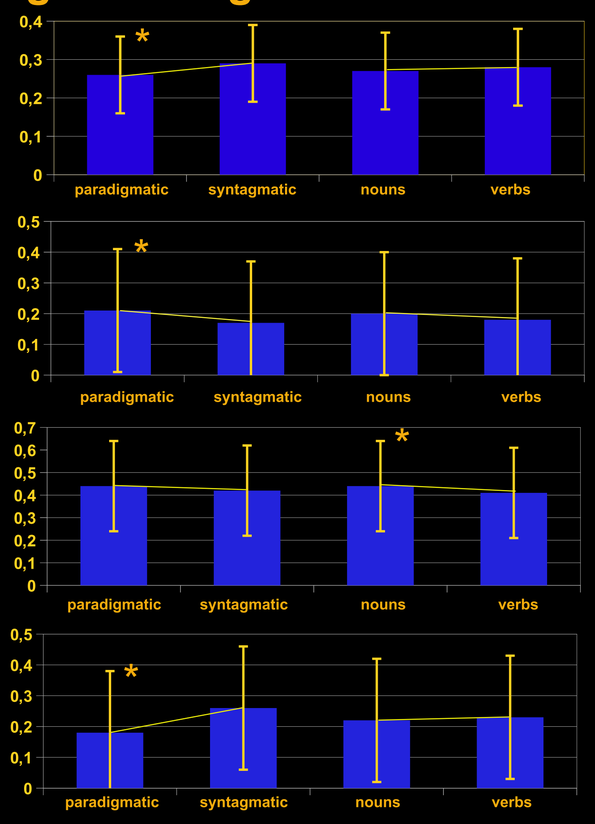


Fig.4 STS



Response time

Fig.5 Response time

Discussion

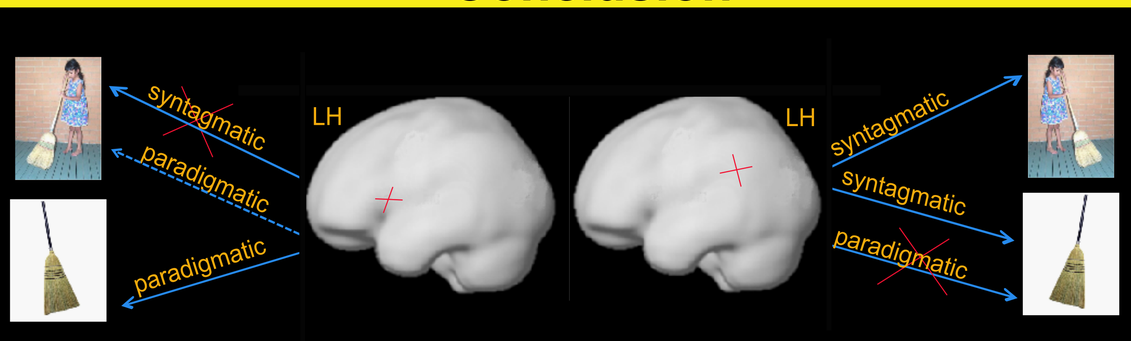
As we supposed, the factor of word retrieval strategy contributes to the percent signal change in pars opercularis of inferior frontal gyrus, superior temporal gyrus and temporo-parietal region. No contribution of grammatic class factor has been found (Fig. 1,2,4).

The contribution of STS in word retrieval using syntagmatic relations (Fig. 4) is task specific: we used the pairs of words with grammar flexions for word retrieval rely on syntagmatic strategy, while for word retrieval rely on paradigmatic strategy we used the words in the initial form. According to the previous research, both superior temporal gyrus and inferior frontal structures contribute into processing of words whith grammar flexions and regular morphology (Marslen-Wilson, Tyler, 2005).

It has been found that grammatic class factor influence on percent signal change in pars triangularis of inferior frontal gyrus (Fig. 3). This result can be interpreted as evidence for distinct cortical representation of nouns and verbs. We suppose, that this result can be explained in another way. The activation in the inferior frontal gyrus increases for selective retrieving words among competing alternatives (Kan & Thompson-Schill, 1997, 2004). Also we know that verbs are more polysemous and we use restricted number of verbs in our speech compared to nouns (Gentner, 1981), the class of nouns is wider then the class of verbs thus it requires more activity from inferior frontal gyrus (Thompson-Schill, 1997, 2004).

According to the response time data (Fig. 5) retrieving verbs using paradigmatic relations is more difficult than using syntagmatic ones and there are no significant differences in the response time for nouns retrieval. This facts indicate that the paradigmatic relations of verbs are very poor and less effective for verbs retrieving than syntagmatic.

Conclusion



References

Luria A.R. (2007) Osnovnye problemy neyrolingvistiki // 2nd edition., M.: LKI, - 256 p. Jakobson, R. (1964) Towards a linguistic typology of aphasic impairments. In A. V. S. deReuck and M. O'Connor (Eds.), Disorders of language (pp. 21-41). Boston: Little, Brown.66. Gentner, D. (1981). Some interesting differences between verbs and nouns. Cognition and Brain Theory, 4, 161-178; Thompson-Schill, S.L. et al. (1997) Role of left inferior prefrontal cortex in retrieval of semantic knowledge: a reevaluation // Proc. Natl. Acad.Sci. U.S.A. 94, 14792-1479. Marslen-Wilson, W. D., Tyler L. K., (2005) The lexicon, grammar, and the past tense: Dissociation revisited // Tomasello, M. & Slobin, D. (Eds.) Beyond Nature-Nurture: Essays in Honor of Elizabeth Bates. Mahwah, NJ: Lawrence Erlbaum, P. 263-279. Crepaldi D. et al. (2004) Naming of nouns and verbs in aphasia: Preliminary results of a word retrieval task in a sentence context// Brain and Language 91, 150-151. Tyler L.K. et al. (2004) Neural processing of nouns and verbs: the role of inflectional morphology // Neuropsychologia. 42, 512-523. Damasio, Tranel (1993) Nouns and verbs are retrieved with differently distributed neural systems // PNAS 90, 4957-4960.